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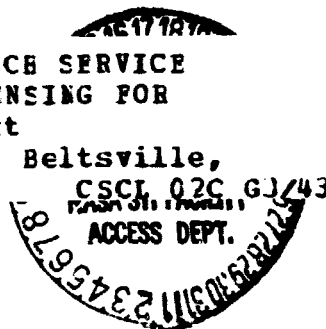
AGRICULTURAL RESEARCH SERVICE RESEARCH HIGHLIGHTS IN REMOTE SENSING FOR CALENDAR YEAR 1981

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AGRICULTURAL RESEARCH SERVICE RESEARCH HIGHLIGHTS

IN

REMOTE SENSING FOR CALENDAR YEAR 1981

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ORIGINAL PAGE IS
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Agricultural Research Service Research Highlights
in
Remote Sensing for Calendar Year 1981

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This report is a compilation of selected examples of research accomplishments related to remote sensing by Agricultural Research Service (ARS) scientists during calendar year 1981. A brief statement is given to highlight the significant results of research projects. A list of 1981 publication and location contacts is given also. More details on specific research projects and copies of publications can be obtained from the specific location contact.

This report was abstracted from the annual research progress reports prepared by ARS research scientists and is part of the ARS Annual Report on Soil, Water, and Air Research Accomplishments. Copies of the Annual Report of the Soil, Water, and Air Sciences Research can be obtained from Jerry C. Ritchie.

I would like to acknowledge the input of each ARS scientist whose research contributed to this report and the assistance of Sara Jean Binder in the preparation of the copies of the text.

Special Research Program

REMOTE SENSING

Remote sensing is a technology (tool) that has the potential to provide data for many action agency programs and ARS research programs. The ARS research mission in remote sensing is to develop the basic understanding of the soil-plant-animal-atmosphere continuum in agricultural ecosystems and to determine when remotely sensed data can be used to provide information about agricultural ecosystems. Once these systems are understood, systems and models can be developed that use remotely sensed data efficiently and effectively. Remote sensing research is carried out under four general technological objectives as follows:

1. Secure a better understanding of the emission and reflectance properties of biological and physical parameters through spectrophotometric analyses in the laboratory, in the field, and from low altitudes and space.
2. Develop procedures for utilizing remote sensing techniques for identifying crops and for measuring their acreage, stage of growth, and health as affected by disease, insects, nematodes, weeds, and by other environmental factors such as nutrition, salinity, soil moisture, erosion, temperature, and pollution.
3. Develop remote sensing methods to improve water and soil management, soil erosion control (wind and water), sedimentation control, soil mapping, watershed planning, water supply and runoff forecasting, and establishing land capability.
4. Continue efforts to investigate, develop, and utilize information obtained from the unique characteristics of space-acquired remote sensing data which are not available by ground and aerial means, and continue to develop the use of that data to improve the speed, coverage, and accuracy of surveys now done by conventional ground and aircraft techniques.

Research under these technological objectives is funded and performed under the appropriate National Research Program (NRP). The following locations and NRPs contribute to the remote sensing program.

SRP Contact: A. R. Grable/J. C. Ritchie

Research Locations and NRPs:

Weslaco, Texas	20220	Bushland, Texas	20760
Tifton, Georgia	20240	Houston, Texas	20760
Weslaco, Texas	20280	Temple, Texas	20760
Gainesville, Florida	20740	Weslaco, Texas	20760
Bushland, Texas	20740	Raleigh, North Carolina	20790
Phoenix, Arizona	20760	Watkinsville, Georgia	20800
Akron, Colorado	20760	Oxford, Mississippi	20800
Fort Collins, Colorado	20760	Columbia, Missouri	20800
Gainesville, Florida	20760	Durant, Oklahoma	20800
Urbana, Illinois	20760	Pullman, Washington	20800
Beltsville, Maryland	20760	Tifton, Georgia	20810
Mississippi State, Mississippi	20760	Boise, Idaho	20810
Sidney, Montana	20760	Beltsville, Maryland	20810
Mandan, North Dakota	20760	Durant, Oklahoma	20810
Pendleton, Oregon	20760	Temple, Texas	20810

Examples of Recent Progress:

Color IR photography used to determine overwinter boll weevil habitat - Weslaco, Texas (20220). Color infrared (IR) photography is being used to compare areas with persistent boll weevil infestations and areas with insignificant boll weevil infestations. In an effort to reduce overwintering boll weevil populations, an aerial survey using color IR photography is being developed to aid regulatory agencies in verifying compliance of cotton plow-up regulations. Compliance with these regulations reduces overwintering boll weevil populations.

Color IR photography used to detect white rust - Weslaco, Texas (20220). Color IR aerial photography was used to detect white rust (*Albugo occidentalis*) infection in spinach. Differences between 4.8 and 7.1 percent infected leaf areas were detected in variety plots. Fungicide treatments can be initiated at this level of infection in order to protect the crop. This technology will allow management decisions to be made earlier.

Technique developed to reduce film damage due to dry atmospheric conditions - Weslaco, Texas (20220). Atmospheric conditions can cause deterioration of color IR film, requiring a delay of several seconds or longer between exposures of single frames. A technique was developed that allowed moist air to enter the camera, thus preventing drying of the film emulsion. Before this technique was developed, at least two frames had to be exposed immediately before photographing the desired area. This technique will result in less film being used.

Radar detects insect movement - Tifton, Georgia (20240). An entomological radar was used to study the flight behavior of insects and associated wind patterns. Insect activity increased and generally reached a maximum about one hour after sunset. When insect layers occurred, the layers formed three or four hours after sunset on clear nights with relatively stable air. Simultaneous measurements of wind patterns frequently revealed winds that were not evident on synoptic charts. Insect dispersal under these conditions was greater than that predicted from conventional modeling. Several heavily infested peanut and sorghum fields were located with the aid of radar by detecting plumes of insects leaving the fields. The plumes had half lives of about 15 minutes. The radar also detected a cloud of insects extending at least 80 meters above a lighted football field. Apparently, the insects' flight behavior was affected by the lights which produced an accumulation of insects above the football field.

Cooperative research improves entomological radar information - Tifton, Georgia (20240). NASA (Wallops Island, VA) brought equipment to Tifton, GA for a 3-week field exercise. Radar video and antenna position information from the USDA radar was digitized by NASA and recorded on magnetic tape. The hardware exceeded reliability expectations and was able to digitize 1000 successive points from every fourth radar pulse. The fastest sampling rate was 10 nanoseconds per point (every 1.5 meters in range). Software for interpreting the radar data indicated that the sampling system could produce qualitative data similar to the conventional USDA radar display.

Field verification of radar detection of insects - Tifton, Georgia (20240). Plumes of dispersing insects emanating from point sources near Tifton, Georgia were detected 15 to 30 minutes after sunset during August and September of 1981. Two different fields of peanuts and sorghum were identified as contributing or responsible for the plume effects. Subsequently, observations were made on successive nights to correlate insect flight activity with RADAR sightings. The peak activity observed at canopy level and above corresponded to the time and appearance of plumes sighted on RADAR, indicating the usefulness of RADAR for determining insect movement.

Weeds detected with aerial photography - Weslaco, Texas (20280). Reflectance data from plant canopies generally showed greater weed-crop species differences at 0.85μ (photographic IR) than 0.55μ (visible). These data predicted that color IR (CIR) photographic film would detect weed populations in several crop species more efficiently than would conventional color (CC) film. Climbing milkweed (*Sarcostemma cyanchoides*) reflectances at 0.85μ were greater than those over orange trees; CIR film was superior for aerial survey at 5,000 ft. (1524 m) elevation. Reflectance (0.85μ) over white-flowered ragweed (*Parthenium hysterophorus* L.) was greater than over bell pepper. Reflectance (0.85μ) was greater with johnsongrass than with maturing grain sorghum and detection at 60,000 ft. (18,000 m) elevations with CIR film correlated well with ground truth data; 185,000 acres (75,000 ha) were surveyed in each photograph. These type of data can be used to compute acreages of weed populations in cultivated crops.

Thermal inertia maps of Florida developed - Gainesville, Florida (20740). Work has been undertaken to develop thermal inertia maps of Florida using remotely sensed and other data. Preliminary findings show that surface thermal inertia is highly correlated to the soil drainage class. The excessively drained and well-drained soils have lower thermal inertias and larger ranges of daily maximum and minimum temperatures. The poorly-drained soils, wetlands, and especially bodies of water have higher thermal inertias and smaller ranges of daily maximum and daily minimum temperature. These studies indicate the potential use of remotely sensed data for detecting drainage problems.

Full season spectral data set for water stressed wheat, barley, corn, sorghum and sunflower collected - Bushland, Texas (20740). Full season spectral data were taken once or twice a week on several treatments of water stressed wheat, barley, corn, sorghum, and sunflower using a Mark II 3-band radiometer. Canopy-air temperature differentials were taken daily during stress periods for characterizing stress using a stress-degree-day or crop water stress index approach. Additional periodic water status measurements taken for evaluating deficits or stress were soil water; leaf water, osmotic and turgor potentials; and leaf diffusive resistance and transpiration rate. Plant measurements made for correlation with spectral reflectance were green leaf area, green and dry biomass, ground cover, and development stages. Analysis of the extensive data collection will permit an evaluation of the use of remotely sensed data for early detection of stress in crops.

Infrared thermometer (IRT) measurement of sunlit leaves best for irrigation scheduling - Bushland, Texas (20740). The IRT was tested for evaluating plant water deficits and the need for irrigation on 6 crops (wheat, barley, corn, sorghum, soybean, and sunflower) as a remote sensing measurement. The data suggest that when the IRT is used by a ground observer for assessing water deficits and scheduling irrigation, that it be used only for sensing temperatures of upper sunlit leaves, perhaps using a down-the-row integration

of many plants. Stress in corn was detected with the IRT before it became visually evident, which could enhance its usefulness in irrigation scheduling of a stress sensitive crop.

Crop water stress index applicable under varied environmental conditions - Phoenix, Arizona (20760). A crop water stress index was evaluated for well-watered alfalfa at 4 locations in the United States. It was found that the index described the plant water stress equally well in Arizona, Kansas, Nebraska, and Minnesota. This demonstrates the applicability of the crop water stress index under a wide variety of environmental conditions. The index has been shown useful for quantifying crop stress for the purposes of scheduling irrigations and for predicting crop yields.

Atmospheric conditions affect satellite data interpretations - Phoenix, Arizona (20760). A turbid atmosphere can considerably reduce our ability to discriminate between stressed and nonstressed vegetation using satellite-derived spectral reflectance data. Ground measured data are useful for developing relationships between agronomic parameters and remotely sensed parameters. The extension of the ground data to what would be measured from a sensor on a satellite requires accounting for atmospheric effects. The results show that atmospheric turbidity could greatly influence our interpretation of satellite reflectance parameters.

Theoretical stress model applicable in arid and humid regions - Phoenix, Arizona (20760). Data for 2 years (one very dry and one wet) have shown that the theoretically driven crop water stress index is well correlated with corn yield, mainly because of the accounting for net radiation, a necessary requirement for cloudy conditions. This is the first instance where a yield model developed under arid conditions has predicted yields in a humid environment.

Hot wind effects on winter wheat development and yield defined - Akron, Colorado (20760). Hot wind damage to winter wheat is the most severe when the plants are in the heading-to-flowering growth stage and decrease from these growth stages to maturity. At heading and flowering the plants abort complete tillers, during the milk growth stage heads abort kernels and kernel weight is decreased and after milk growth stage weight per kernel decreases.

Simulation model for growth initiation in wheat developed - Akron, Colorado (20760). A dynamic materials balance model to simulate the growth, development, and grain yield of winter wheat has been developed. The sensitivity of the model to climate, soil water, and soil nutrient factors has not been fully determined and is anticipated to be an ongoing process as cultural systems change and new varieties become available. The prediction of growth initiation after winter dormancy, one of the criteria necessary for the success of any winter wheat simulation model, has been successfully modeled.

Snowpack model developed - Fort Collins, Colorado (20760). A model was developed to simulate a shallow-type snowpack which occurs during the overwinter period in the central and northern Great Plains. The model uses standard data from Class A weather stations. Using data from Mandan, North Dakota, tests show a good simulation of snow water content with snowpack accretion (depth). The model can be used in winter wheat growth and yield models to help identify early warning of winterkill and estimates of spring water content.

Data set collected to validate wheat models - Fort Collins, Colorado (20760). The data sets collected on 7 central Great Plains locations to validate wheat models are now in the final stages of cleaning, the errors have been corrected, and missing values estimated. For all the weather parameters measured, isolated missing hourly values were interpolated. Where a substantial number of hourly values were missing, daily estimates were made for six of the parameters. These were average soil temperatures at 1 and 3 cm depths, solar radiation, maximum and minimum air temperatures, and precipitation. The set will be available to modelers to validate wheat models.

Wheat model developed - Fort Collins, Colorado (20760). A simulation model for estimating wheat yields has been completed. The literature was reviewed and algorithms developed for estimating the water use, phenology, and grain yield. The Priestly-Taylor equation was used for estimating evapotranspiration. The germination and initial growth was developed as a function of moist soil degree days. Algorithms were developed for estimating the tiller development and subsequent tiller deaths. The grain yield was estimated based on environment following jointing and on to maturity. The model also estimates leaf area development and senescence. The model was partially tested against a data set from Akron, Colorado, and gave reasonable data.

Leaf area in soybean related to date of transition from vegetative to reproductive growth - Gainesville, Florida (20760). Leaf area development is an important variable in influencing crop CO_2 assimilation. Data were collected under field conditions to determine possible variability in the rates of leaf production among 35 soybean cultivars (ranging from maturity group 0 to VIII). In fact, all cultivars had essentially the same leaf production rate showing a linear temperature response. The main variable in determining final crop leaf area was the date of transition from vegetative to reproductive growth. This transition occurred earliest in the more northern lines thereby resulting in fewer leaves. This information is necessary for accurate simulation of soybean yield.

Soybean management model developed and tested - Urbana, Illinois (20760). A soybean crop growth model and soil water balance model were combined to study the effects of irrigation management strategies on soybean yield and profit. The combined model was used to simulate field plot irrigation experiments in Gainesville, Florida. Simulated yields were found to compare favorably with experimental yields. Seventeen years of historical weather data were used to study the effects of various irrigation strategies on expected yield and profit when using a center pivot irrigation system. Strategy components were allowable soil profile depletion and amount of water per application. Uncertainties, or risks, associated with yield and profit for each strategy were expressed as variances of simulated yields and profits resulting from year-to-year variability in weather. Results of the model indicate that a strategy of light, frequent irrigation with incomplete wetting of the depleted soil profile maximizes expected profits for sandy soils under uncertain rainfall distribution patterns. Results also suggest that risks associated with profit and yield are reduced by this irrigation strategy. (University of Florida)

Soybean leaf photosynthetic controlled by day length - Urbana, Illinois (20760). Leaf photosynthetic rates within a genotype are controlled by day length during the vegetative and flowering states. Such leaf photosynthetic rates were correlated with the degree of pod set which, in turn, was controlled by the day

length during the floral period. By controlling the timing of flowering and pod set and the degree of pod set among genotypes via daylength manipulations, meaningful comparisons of leaf photosynthetic rates should be possible.

Spectral measurements related to corn yields - Beltsville, Maryland (20760). Significant relationships were found between corn grain yield and remotely sensed reflectance. One year's corn yield data, from ground based experiments, showed that about 50 percent of the variation in yield could be associated with spectral measurements in wavelengths corresponding to Landsat-D's thematic mapper bands TM3 and TM4. TM5 informational input was about the same as TM3 input but slightly less sensitive in this nondrought stressed experiment.

Improved algorithms developed for wheat model - Mississippi State, Mississippi (20760). A mechanistic, iterative system for calculating leaf temperature, leaf water potential, transpiration and soil water evaporation was developed and partially incorporated in the WHEAT model. The soil temperature subroutine of the RHIZOS section of WHEAT was replaced by a more general one for use in grassland models. A model simulating the active uptake of ammonium, nitrate, and phosphorus was incorporated in the RHIZOS section of WHEAT. These techniques will improve the accuracy of the simulation of wheat growth.

Cotton model (GOSSYM) improved and validated - Mississippi State, Mississippi (20760). The GOSSYM model was modified to produce no more than one vegetative branch and to partition photosynthate with a preference for fruit growth. Certain changes in RHIZOS were made to accept a particular type of soil input data from validation efforts in Israel. With these changes in place, GOSSYM was run with 57 soil/climate data sets representing 19 different locations and 3 years in Israel. Seasonal time courses of predicted plant height, numbers of fruiting sites, squares and bolls, as well as weights of stem, leaves, and bolls per plant were compared against real data. Agreement between the model and the real crop characters were excellent. A few exceptions in fruit numbers occurred, suggesting a few instances of insect damage which were not simulated.

Soybean model verified and validation test begun - Mississippi State, Mississippi (20760). Verification has been completed. The first validation runs against data from a 1979 Mississippi crop revealed deficiencies in the mechanism for controlling leaf and petiole abscission. Inserting additional criteria for leaf drop partially solved this problem. Some of the parameter controlling organ expansion required modification. A comparison of observed and simulated organ dry weight gains suggested that photosynthetic efficiency increased over the season. Confirmation of this and a rationale to model it are being sought. Early validation runs against dry and irrigated 1980 Florida crops were encouraging.

Wheat stand densities detected by air-borne radiometers - Sidney, Montana (20760). Aircraft overflights showed that air-borne radiometers corresponded closely to handheld radiometers in delineating variable wheat densities at 20, 40, and 100 percent of normal seeding and that near IR to red ratios at the heading stage were closely related to grain yield. The development of this capability will help in detecting winterkill of winter wheat, predicting yields, and potential need for reseeding to spring wheat.

Forecasting annual herbage production on rangelands - Sidney, Montana (20760). A yield-forecasting technique utilizing a range forage production model and historical climatic data was developed. The first forecast is made at the beginning of the growing season and can be updated periodically to the time of peak standing crop. Utilizing available soil water at the beginning of the growing season as initial boundary conditions, the model calculates a yield index for each year of historical climatic data used. A mean and confidence interval can be calculated and used to make yield forecasts at various probability levels. In a cooperative project with the Bureau of Land Management (BLM), this forecasting technique was applied to over 40 range sites in eastern Montana during 1981. The results were used by BLM personnel in their resource planning.

Wheat yield variations measured as part of wheat model validation data set - Mandan, North Dakota (20760). Over a period of 3 years at 13 AgRISTARS field locations and 4 experimental sites, grain yield varied from 940 to 3982 kg/ha based on 225 and 101 observations on hard red spring wheat (HRS) and durum cultivars, respectively. The number of heads/unit area accounted for 49 percent of HRS grain yield variability, kernels/head for 21 percent and kernel weight for 23 percent. By contrast, in number of head/unit area accounted for 21 percent of the durum yield variability, kernels/head, for 43 percent and kernel weight, for 34 percent. This data will be used to validate wheat yield and growth models.

Wheat yield related to growing degree units (GDU) - Mandan, North Dakota (20760). To develop an understanding of response of HRS and durum wheat to soil and environmental parameters, wheat cultivars were observed at least thrice weekly and sampled as needed to evaluate rate of phenological development and of dry matter accumulation in relation to ambient temperature, expressed as GDU. All but one cultivar of HRS and durum wheats developed 8 leaves. Rate of leaf insertion and development as well as the four growing stages after full flag leaf expansion require about 80 GDU/event. About 930 GDU (C°, base = 0) are required from emergence to anthesis, stage 0 to stage 11.6 Haun scale. Dry matter accumulation in HRS and durum wheat grain, from anthesis to maximum accumulation requires about 750 GDU. Over the linear accumulation phase (the accumulation curve is sigmoid) HRS cultivars require 25 GDU/mg/kernel and durum 17 GDU/mg/kernel.

A plant-centered measure of environmental stress in cereals - Pendleton, Oregon (20760). A new method of specifying each leaf and tiller on a cereal plant permits the life history of a crop to be followed during its development. Areal seedlings produce specific tillers at definite "windows" of time unless stress occurs. Stressed seedlings omit or delay production of those tillers which were due to appear during the period of stress. After stress has been relieved, the plant returns to the normal pattern of tiller production. Thus, by looking at the specific tillers present on a plant, it is possible to determine whether the plant has been stressed and the approximate time of the stress.

Stress indicator models developed for Foreign Agricultural Service (FAS) - Houston, Texas (20760). Development and testing of the Maize stress indicator model with domestic meteorological and ground truth data were continued. A grain sorghum stress model was developed and is being tested further. Parameters and threshold values were defined for a sugarbeet planting/harvest stress indicator model. A literature search has begun to initiate the in-house

development of a stress model for cotton crops. Improvements have been developed and evaluated for determining the degree of hardening in winter wheat and for accuracy of the Robertson winter wheat crop calendar. These models are for use by FAS to monitor crop conditions worldwide.

Soybean stress model being adapted - Houston, Texas (20760). Work continued on the conversion and adaptation of the Hill Soybean Model as a global predictor of stress. Ground truth information was collected and collated with meteorological data for model testing and evaluation. Studies began on program adjustments, particularly phenology reorganization, to include all major South American maturity groups. A preliminary model was delivered to the in-house technical monitor for evaluation.

User-oriented wheat yield model developed - Temple, Texas (20760). A computerized model of wheat production was developed for use in farm risk analysis, in large area yield estimation, and in economic policy analysis. The daily incrementing model was designed to take a minimum amount of information regarding soils, management, genetics, and weather to calculate the estimated yield along with other information regarding the grain numbers, grain weight, biomass production, tiller and head numbers, and soil water balance. Use of quantitative genetic specific constants has made it possible for the model to be generally applicable for spring or winter wheat and requiring no regional calibration and is relatively accurate when compared to measurements from research plots in several countries.

New technique developed to improve the limits of soil water availability to plants - Temple, Texas (20760). Field measurements of the soil water content at the lower limit (wilting point) and upper limit (field capacity) are often quite different to approximations of those limits made in laboratory determinations. Equations were developed using only combinations of soil texture percentages to estimate the limits of water availability and found them to correlate well with field-measured limits. This will make possible a more accurate large-scale mapping of plant available water limits for the U.S., a critical factor in the evaluation of water deficit impact on yield.

Satellite and ground collected solar radiation data compared - Temple, Texas (20760). Hourly solar radiation data were collected from 3 locations in the U.S. representing contrasts in altitude, latitude, and longitude for further testing of the capability of using geostationary satellite information to estimate daily solar radiation. This program is, in addition to an existing operational satellite system, being tested for all the U.S. east of the Rocky Mountains. The specific tests conducted are providing information regarding the generality of the methods being used in the operational system. Information obtained in 1981 indicates that consistent deviations from present estimation procedures occur in humid regions near the Gulf of Mexico on mostly clear days.

Corn growth model under development - Temple, Texas (20760). The description of corn vegetative growth was found to be possible using only 2 genetic specific parameters. These are the basic degree-day requirement for tassel initiation under short photoperiods and the photoperiodic sensitivity of tassel initiation. Final leaf number can be determined from the length of the interval from seedling emergence to tassel initiation. Date of tasseling, in turn, can be determined from final leaf number. Potential kernel number/ear is determined using the average rate of photosynthesis during a fixed time interval near

silking. Short-term stresses in this interval can have drastic effects on final yield. Reproductive development and yield are described by two genetic specific parameters--length of the tasseling to maturity interval and rate of grain fill. All growth processes in the model are affected by soil water deficits that are evaluated with a soil water balance submodel. Testing of various parts of the model using available data sets is being done to evaluate the generality of the model.

Satellite detects freeze-inhibiting atmospheric layer - Weslaco, Texas (20760). The thermal channel of the Heat Capacity Mapping Mission (HCMM) satellite detected an atmospheric layer that, while not visible to ground observers, retards the earth's radiation loss to space on a freeze night. This satellite's ability should have an important application in real-time freeze forecasting. Knowledge of the presence of the retarding layer would justify an upward revision of forecasted minimum temperatures to save growers from using expensive freeze protection measures.

Technique for measurement of reflectance factors developed - Weslaco, Texas (20760). A technique for measuring reflectance factors in diurnal and intermittent cloud insolation conditions using handheld radiometers has been developed. The estimated reflectance factors of four reference panels, using the MARK2 three-band handheld radiometer, agreed closely with the expected reflectance, measured with a laboratory spectrophotometer, over a wide range of insolation (from 20 to 91 mW/cm²). This technique will be useful to achieve uniform reflectance factors for small-scale remote sensing field studies where irradiance is continually changing.

Procedure for following crop development and stress - Weslaco, Texas (20760). Heat Capacity Mapping Mission (HCMM) observed temperatures for sorghum, citrus, sugarcane, cotton, and pastures were related to vegetation indices that were calculated from LANDSAT data acquired within four days of the HCMM overpass dates. Vegetation indices can be automatically computed from satellite data and are related to plant cover amount in row crops and rangeland. Therefore, it is expected that surface temperatures observed by operational meteorological satellites would be related to vegetation indices and would be useful to follow seasonal crop development and to detect stresses such as drought.

Aridity index being developed from meteorological satellite data - Weslaco, Texas (20760). Aridity indices increased with distance inland corresponding to change from mixed irrigated cropland to rangeland in the interior and to area-wide rainfall. For universal application, an aridity index is being developed from the two thermal channels of the meteorological satellite, maximum and minimum air temperatures at ground stations, and the sun's ephemeris at satellite overpass.

Natural accumulation of litter under range vegetation does not affect reflectance - Weslaco, Texas (20760). Reflectance was measured for 1-m² range grass plots with two canopy treatments (standing and clipped), four levels of litter accumulation, and grain sorghum with the two canopy treatments. Reflectance was significantly higher at the 0.65 to 1.65 and the 2.20 μ m wavelengths for both grass (*Andropogon scoparius* cv *lilloralis* (Nash) Hitchc) and grain sorghum (*Sorghum bicolor* (L.) Moench) canopies when the canopies were clipped and the clippings were removed. The natural accumulation of litter under standing grass canopies did not affect reflectance.

Spectral measurement of nitrogen stressed wheat measured - Bushland, Texas (20780). Spectral measurements were made on nitrogen and water stressed wheat. These experiments were developed to determine if nitrogen stress could be measured remotely.

Spectroradiometer system designed to measure ozone/damage - Raleigh, North Carolina (20790). A spectroradiometer system for obtaining spectral signatures of crops growing in open-top field chambers has been designed. All of the major components have been received. The system will be field tested during the 1982 growing season. Spectral signatures of O₃ injured snapbean plants obtained with a portable ISCO model SR spectroradiometer are currently being analyzed to develop statistical methods for comparing spectra.

Erosion mapped by photography - Columbia, Missouri (20800). Mapping of the time lapse photography was continued and when the most recent maps are available, the pattern of erosion since 1969 can be reconstructed. Alluvial-colluvial deposition was quantified using standard surveying data from 1962 and 1980 to compare with the photography.

Remote sensing technique for estimating runoff and sediment yield developed - Durant, Oklahoma (20800). A successful remote sensing technique was developed using standard 1:20,000 ASCS aerial photographs to determine the drainage density of small watersheds and correlating that parameter to average annual runoff and sediment yield. Seventeen watersheds in the Southern Plains were used in the study. This technique provides a rapid method of estimating runoff and sediment yields from routinely available data.

Application test of SPAW model continues - Pullman, Washington (20800). Several application tests of the soil-plant-air-water (SPAW) model were conducted. Soil moisture data from the summer fallow region of eastern Washington were analyzed and reported. Researchers at several locations including NASA-JSC in Houston, Texas; Boise, Idaho; and Kansas State University are testing and applying the SPAW model. Results have been quite good in most cases. The SPAW model was reprogrammed to reduce it to a subroutine version for insertion into broad-scale hydrology models. The internal procedures were preserved.

Instrumentation research continues for SNOTEL - Boise, Idaho (20800). Cooperative SCS SNOTEL instrumentation research produced an electronic interface between their isotopic snow gage and the SNOTEL transmitter at More Creek Summit, Idaho. Installation and testing were completed. Also, a snow pillow transducer test instrument was completed, delivered, and installed.

Analysis indicates some snow course data may not be necessary - Boise, Idaho (20810). Regression analysis revealed some redundancy in snow water equivalent data being collected at the snow courses in and around the Boise River drainage. This suggests that a comprehensive analysis of the snow course network could indicate sites that contribute little, if any, additional information for preparing the water supply forecast. There were insufficient concurrent SNOTEL and snow water equivalent data available to replace the snow course measurements with SNOTEL pillow observations in the forecasting regression equations. At least one more year of SNOTEL data will be necessary before progress can be made.

User manual for determining SCS curve numbers from Landsat data prepared - Beltsville, Maryland (20810). A manual for using remotely sensed data to estimate the land cover requirements of the SCS curve number was prepared. This was presented to the SCS in several workshops. This manual consists of step-by-step instructions for using Landsat data to calculate runoff curve numbers for complex watersheds. This approach gives the SCS and others an extremely cost effective method to be used in watershed planning. Accuracy is comparable to SCS conventional techniques for watersheds larger than about one square mile.

Vegetation effects eliminated in microwave measurement of soil moisture - Beltsville, Maryland (20810). Data collected over the Beltsville Agricultural Research Center plots using the microwave radiometers were used to evaluate a theoretical model of the effect of vegetation cover on the emission of soils. These studies showed that the effect could be accounted for when a readily obtained vegetation parameter was included and the appropriate wavelength was used. Results also showed that this approach could provide reliable soil moisture estimates except under heavy vegetation cover, i.e., forest. These results pave the way for experiments with microwave remote sensing in many agricultural hydrological applications.

Optimum timing and selection of channels in existing satellites determined - Beltsville, Maryland (20810). Study of data from the Advanced Very High Resolution Radiometer on NOAA 6 satellite showed that the early morning observation time results in thermal infrared (temperature) data which are unsatisfactory for assessing surface moisture conditions. However, preliminary evaluation shows that data from the afternoon satellite (NOAA-7) are of much better quality. The mid infrared channel ($3.7\mu m$) measures a combination of reflected sunlight and surface emission, making analysis ambiguous. The thermal infrared data ($11\mu m$) are suitable for analysis in conjunction with numerical models of surface temperature. This information defines which satellite data will be useful in water balance and temperature work.

Large-scale evapotranspiration rates obtainable from satellite data - Beltsville, Maryland (20810). A previously developed analysis method was applied to a day-night pair of satellite thermal infrared image acquired over eastern Washington State. The derived estimates of evapotranspiration (ET) were consistent with values for well-watered crops as given by the Penman equation and by pan evaporation values, i.e., about 10 mm/day in the irrigated areas along the Columbia River. However, the satellite data yield ET values on a regional scale, illustrating the full range of values between uncropped areas (near 0 ET) and the irrigated farmland. Surface moisture availability (ET/ETP) was found to vary between 0 and 1.0. This analysis demonstrates that large-scale water balance work can be done using remotely sensed data.

Algorithm developed for estimating surface temperatures from satellite data - Beltsville, Maryland (20810). An algorithm has been developed and programmed for estimating surface temperatures, given pairs of measurements in the thermal infrared, as are now available from operational satellites. The predicted correction for the radiative effects of moisture in the atmosphere can be greater than $10^{\circ}C$. Omission of this correction in the interpretation of satellite data would lead to highly erroneous values for surface properties.

Soil Moisture Sampling Criteria Established - Beltsville, Maryland (20810). Two studies were conducted to evaluate the variability of soil moisture and its interaction with physiographic features. The accuracy of gravimetric soil moisture measurements was shown to be function of sample volume. When characterizing the surface soil, samples of at least 30 cm³ must be used. The influence of several factors on soil moisture variability was evaluated. Statistical tests showed that land cover, antecedent meteorological conditions and topography had significant influence on both the mean and variance of the soil moisture. Systematic soil moisture variations were found within smooth, low-slope watersheds that were homogeneous in land cover and soil type. This research provides a basis for design of ground truth soil moisture sampling programs that support remote sensing experiments.

Initial soil moisture values used in hydrologic models is very sensitive for most storms - Beltsville, Maryland (20810). A sensitivity analysis was performed to determine the impact of antecedent soil moisture conditions and soil hydraulic properties on the excess rainfall volumes resulting from single event storms. The sensitivity of rainfall excess volumes to moisture conditions depended on the rainfall volume, duration, and distribution. The relative impact of antecedent moisture on rainfall excess volume was significant in the storms with small rainfall volume. An error 0.05 cm/cm in measurement of antecedent moisture resulted in errors of about 20 percent and 100 percent in rainfall excess volume predictions for 3-inch (7.5 cm) and 2-inch (5.0 cm) storms, respectively. In general, errors in the determination of antecedent moisture can affect estimates of rainfall excess significantly. This result suggests that remotely sensed soil moisture may be extremely valuable data for comprehensive hydrologic simulation models.

Spatially distributed infiltration parameters do not improve simulations of runoff - Beltsville, Maryland (20810). A physically based, distributed hydrologic model was used to simulate storm hydrographs for a small 10.8 ha watershed in Oklahoma. This area was chosen for analysis because of its very complete history of hydrologic studies and data including 26-ring infiltrometer measurements. The best simulation results were obtained from lumped parameters developed from the mean of the ring data, from optimized rainfall-runoff data, and from basic soil properties. Distributing the infiltration parameters according to soils or the location of the infiltrometer measurements did not improve the simulations. The results of this study illustrated that a practicing hydrologist could get good results from a comprehensive, physically based model and that the infiltration parameters could be determined without field surveys or data collection programs.

Generation of daily weather variables - Temple, Texas (20810). A model for generating daily values of precipitation, maximum and minimum temperature, and solar radiation was simplified for application to hydrologic models. Maps of the parameters required for generating temperature and radiation were developed so that the parameters could be determined for any location in the United States. Monthly values of the precipitation parameters were determined for 138 locations in the United States.

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